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REVIEW

Event-Related Potential Responses of Individuals with Autism Spectrum Development to Atypical Auditory Processing-a Narrative Review

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Abstract

Purpose of Review This review synthesizes the current literature on event-related potential (ERP) responses to auditory stimulation in individuals with autism spectrum development (ASD), highlighting key findings across various ERP components and stages of auditory processing.

Recent Findings Studies have documented atypicality in early sensory ERP components like the P1 and N1 in ASD, suggesting impairments in initial auditory registration and detection of changes. Findings related to the mismatch negativity (MMN), an index of pre-attentive auditory discrimination, reveal both enhanced and diminished responses, underscoring heterogeneity within the ASD population. Later components associated with auditory attention and resource allocation (N2, P3a, P3b) also exhibit atypicality, indicating difficulties in stimulus classification, attentional orienting, and context updating. Some studies report that increased P3a amplitudes, suggesting hyper-responsivity at the attentional level. ERP components have been linked to co-occurring issues like behavior problems and psychosis risk in ASD.

Summary This review highlights a complex pattern of auditory processing differences in ASD, with evidence of both enhanced and diminished capabilities across various ERP components. These differences may contribute to sensory sensitivities, communication challenges, and co-occurring conditions observed in ASD. The findings underscore the need for further research to elucidate neural mechanisms, explore individual variability, and develop tailored interventions. The complex interplay between sensory processing, attention, and cognitive functions, as well as the heterogeneity within the ASD population, presents challenges but also opportunities for advancing our understanding and improving outcomes.

Keywords Autism spectrum development · Auditory processing · Event-related potentials · ERP

Introduction

Autism spectrum development (ASD) is a neurodevelopmental condition characterized by impairments in social communication and interaction, restricted interests and repetitive behaviors, as well as atypical sensory features [1]. Auditory processing atypicality are frequently reported in individuals with ASD, though the manifestation and severity are heterogeneous across the spectrum. A meta-analysis estimated that approximately 90% of those with ASD exhibit some degree of atypical auditory processing across domains like pitch perception, auditory discrimination, and auditory filtering [2]. More specifically, up to 20% of children with ASD demonstrate profound auditory processing deficits on behavioral tests [3]. At the neurophysiological level, atypical auditory brainstem responses have been reported in over 75% of individuals with ASD [4].

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Among the auditory processing differences commonly reported in individuals with ASD are hyper- or hyposensitivity to sounds, aversions to particular sounds, and difficulties listening in noisy environments [5, 6]. While enhanced abilities in identifying and discriminating isolated acoustic characteristics have been observed, challenges often arise in integrating locally analyzed auditory information into a meaningful whole, suggesting deficits in global auditory processing [5].

Hypersensitivity to auditory stimuli is prevalent in individuals with ASD [7–10], resulting in self-regulatory fear responses and associated with anxiety, depression, and poorer quality of life [11]. The literature suggests that auditory hypersensitivity in ASD is likely caused by atypical processing of auditory stimuli in the brain, rather than a physiological pain reaction [12]. However, both hyper- and hyposensitivity across multiple sensory modalities have been observed [10].

Electrophysiological techniques, like electroencephalography (EEG) and event-related potentials (ERPs), have been really helpful in studying how people with ASD process sounds. These methods that do not require any invasion measure the electrical activity of the brain when it responds to certain sounds, providing insights into the neural processes underlying auditory perception, attention, and discrimination [13, 14]. Researchers can use the amplitude, latency, and scalp distribution of ERP components to understand how different stages of auditory processing work, from the initial sensory registration to the more complex cognitive evaluation.

This review seeks to summarize the existing research on how individuals with ASD respond to auditory stimulation using ERP, focusing on important findings, methodological considerations, and potential areas for future research. It is important to understand how the brain processes sound in individuals with ASD. This knowledge can help us identify ASD at an early stage, develop effective intervention methods, and improve our understanding of how sensory processing differs in this group.

Methods

This narrative review synthesizes research examining ERP responses to auditory stimuli in individuals with autism. Rather than conducting an exhaustive systematic review, we purposefully selected representative studies that demonstrate how ERP components reflect auditory processing in autism.

We organize our analysis around two main categories of ERP components. First, we examine the sequence of auditory processing through P1, N1, N2, P3a, and P3b components, which reflect the progression from early sensory registration to higher-level cognitive processing. Second, we analyze the mismatch negativity (MMN), a extensively studied difference wave that provides unique insights into automatic auditory discrimination [15, 16].

Studies were identified through searches in major databases including PubMed, Web of Science, and PsycINFO. Our selection focused on papers that best illustrate the theoretical understanding of these components' roles in auditory processing, rather than attempting to capture every published study on the topic.

The results are organized by ERP component to provide readers with a clear framework for understanding how each component contributes to our knowledge of auditory processing differences in autism."

Results

This literature review analyzed many crucial ERP components that have been extensively researched in studies on auditory processing in individuals with ASD. These include the first sensory P1 and N1 waves, which indicate the early cortical processing of auditory inputs and the detection of changes, respectively. The discussion also included the concept of mismatch negativity (MMN), which refers to an involuntary and instinctive response to unusual noises that is associated with the ability to differentiate auditory stimuli. Subsequent elements such as the N2, which is related to auditory attention and categorization, as well as the P3a and P3b, which indicate attentional orientation towards novelty and allocation of resources, were also summarized. Together, these components of ERP offer a comprehensive perspective on the temporal progression and neurological foundations of auditory processing, spanning from initial sensory phases to more complex attention and cognitive processes.

P1

Early positive-going ERP component peaking around 50–150 ms following auditory stimulus start is the auditory P1 [17–19]. It arises from neural sources in the primary and secondary auditory cortices located in the superior temporal gyri and surrounding areas in the temporal lobes [18, 19]. The P1 reflects early sensory processing and initial cortical registration of auditory stimuli (see Fig. 1).

Research on P1 in individuals with ASD has yielded varied results, but overall suggests that there is atypical auditory processing during early stages.In a study conducted by Portnova and colleagues in 2023, they discovered that children between the ages of 4—6 years who have ASD exhibited higher P1 amplitude [17]. This indicates that these children have heightened sensory reactivity during the early stages. This aligns with the commonly reported perception of heightened sensory sensitivity in

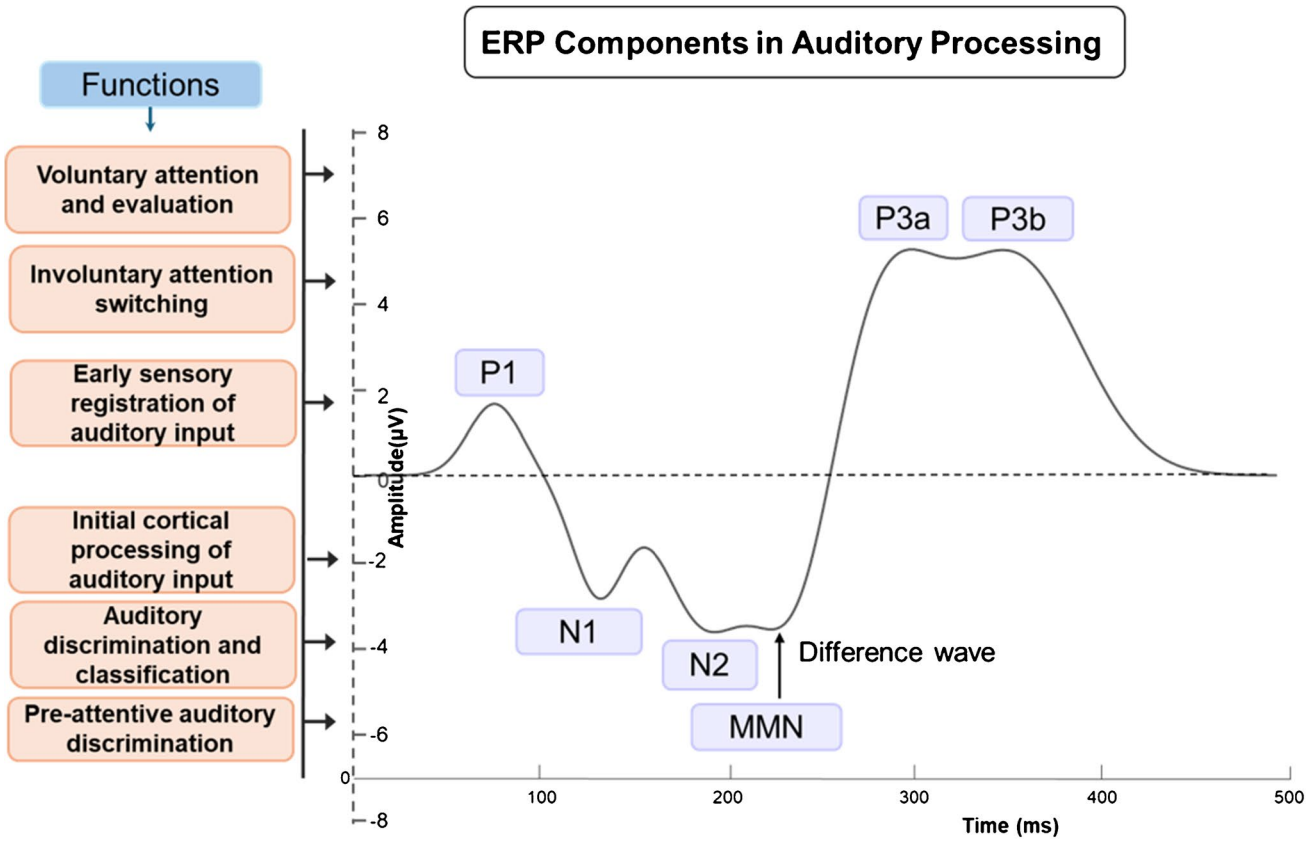

Fig. 1 Composite auditory ERP waveform with distinct peaks. The waveform shows the simulated temporal dynamics of six ERP components: P1, N1, N2, MMN, P3a, and P3b. Note that MMN is a difference wave derived by subtracting standard from deviant responses, while other components are direct ERP responses. Every peak represents the typical size and timing characteristics of the corresponding ERP component. The x-axis represents time in milliseconds (ms) from stimulus onset (0–700 ms), with the 0ms baseline clearly marked. The y-axis represents amplitude in microvolts (μV), with the 0μV baseline indicated. *Note:* The ERP waveforms shown are simulated waveforms intended for reference purposes only. The ERP waveforms may vary because of the way the experiment is set up and because everyone is different. The shapes and timing of the ERP components shown here are not based on exact empirical data, so they should not be interpreted as such

individuals with ASD. On the other hand, Kadlaskar and colleagues (2021) found that children between the ages of 6 and 12 with ASD had lower P1 amplitudes, especially in the central area [20]. This indicates that they may have difficulties with early auditory processing [18]. In a study conducted by Lepistö et al. in 2006, they examined children diagnosed with Asperger's syndrome (which is now considered part of the ASD diagnosis). The researchers discovered that there were no significant differences in P1 differences among the groups of children, indicating that early auditory processing is unaffected in certain subgroups of ASD [3]. It seems that the differences in P1 that have been observed in individuals with ASD may be due to changes in how these particular areas of the brain are working. Overall, these studies show that early auditory processing in individuals with ASD is quite complex. They also stress the importance of conducting more research to gain a complete understanding of the characteristics and effects of P1 abnormalities in this group. Here are the details of the main relevant studies, as shown in Table 1.

N1

The N1 component is a type of brain response to sound that typically occurs 80–120 ms after the sound begins [17, 21, 22]. This component represents initial cortical processing of auditory stimuli [21, 23]. The N1 response provides important insights into early auditory perception and attention mechanisms [24] (see Fig. 1). In autism research, findings regarding N1 characteristics have shown considerable variability [2, 4].

In a study conducted by Bruneau et al. in 1999, it was found that children with ASD had a shorter N1 latency compared to typically developing individuals [19]. This suggests that there may be differences in how the brain processes auditory information in the early stages in individuals with

Table 1 Summary of auditory ERP studies in ASD

Study	Participant	Research Components	Main Findings in ASD	Implications for ASD
Lepistö et al. (2006)	10 AS, 10 TD (7–10 yrs)	P1, MMN, P3a	• No sig. group diffs in P1 • Right-hem. dominant MMN • Larger P1 peak amp; Shorter MMN peak latency	• Comparable early auditory processing • Enhanced later auditory processing and attention
Kadlaskar et al. (2021)	14 ASD, 14 TD (6–12 yrs)	P1	• Smaller P1 mean amp	• Reduced early auditory encoding
Portnova et al. (2023)	25 ASD, 25 TD (4–6 yrs)	P1, N2, P2, P270, LP, N400	• Larger P1 peak amp, Smaller N2 peak amp	• Enhanced early auditory processing & reduced emotional sound analysis
Bruneau et al. (1999)	16 ASD w/ ID, 16 ID, 16 TD (mean 12.3 yrs)	N1	• Shorter N1 peak latency	• Faster auditory signal processing in associative cortex
van Laarhoven et al. (2019)	30 ASD, 30 TD (mean 18.55, 18.83 yrs)	N1, P2	• Maintained N1 peak amp for self-initiated sounds (no reduction) • Reduced P2 peak amp in both groups	• Reduced predictive processing of self-generated sounds
Donkers et al. (2015)	28 ASD, 39 TD (4–12 yrs)	P1, N2, P3a	• Smaller P1 and N2 peak amp to standard tones • Smaller P3a mean amp to novel sounds • Atten. ERPs assoc. w/ more severe sensory seeking behaviors	• Reduced early sensory processing (P1, N2) and reduced attentional orienting (P3a) • ERP measures predict sensory behavior patterns
Donkers et al. (2020)	28 ASD, 17 DD, 39 TD (4–12 yrs)	P1, N2, P3a	• Smaller N2 mean amp to standard tones (in ASD and DD) • Smaller P3a mean amp to novel sounds only in ASD • P1 peak latency unchanged (compared to shorter in DD)	• Reduced early sensory processing (N2) (in both ASD and DD) • Reduced attentional orienting (P3a) specific to ASD
Kujala et al. (2005)	8 AS, 8 TD adults (22–43 yrs)	MMN	• Smaller MMN mean amp & longer MMN peak latency	• Reduced neural processing of speech prosody Slower automatic sound discrimination
Matsuba et al. (2024)	10 ASD, 21 TD (mean 12.7, 12.8 yrs)	P1, MMN	• Larger P1 mean amp & shorter MMN 30% fractional area latency	• Enhanced early sensory processing • Faster automatic sound discrimination
Ferri et al. (2003)	10 ASD, 10 TD males (mean 12.3, 12.2 yrs)	P3a, MMN	• Larger P3a peak amp in young children, smaller in adolescents • Larger MMN peak amp in ASD across ages	• Age-dependent changes in attentional orienting • Enhanced automatic sound discrimination
Vlaskamp et al. (2017)	35 ASD, 38 TD (mean 11.1, 10.9 yrs)	MMN, P3a	• Larger P3a peak amp for duration deviants	• Enhanced involuntary attention to temporal sound changes
Courchesne et al. (1985)	11 ASD, 11 TD (13–25 yrs)	P3b	• Smaller P3b peak amp	• Reduced cognitive resource allocation and reduced context updating for novel stimuli
Sokhadze et al. (2009)	11 ASD, 11 TD (9–27 yrs)	P3a, P3b	• Longer P3b peak latency to novels	• Slower sustained attention processes and delayed context updating
Sokhadze et al. (2017)	32 ASD, 24 TD (9–18 yrs)	N1, P3a, P3b	• Larger P3b mean amp to novel stimuli	• Enhanced resource allocation to novel sounds and Reduced stimulus filtering/selectivity

ASD Autism Spectrum Development, *TD* Typically Developing, *AS* Asperger's Syndrome, *ID* Intellectual Disability, *DD* Developmental Delay, *amp* amplitude, *assoc.* associated, *diffs* differences, *hem.* hemisphere, *sig.* significant, *w/* with, *yrs* years

ASD. It seems that children with ASD might be quicker at detecting initial sounds, and this could affect how they hear things. On the other hand, van Laarhoven and colleagues (2019) examined how N1 attenuation is related to adults with ASD. Researchers noticed that adults with ASD did not show the same decrease in the intensity of the sounds they make, known as N1 attenuation, as typically developing adults do [20]. It seems that when people with ASD process

unexpected sounds, their ability to predict what will happen next is not working properly. This deficit could potentially cause difficulties for individuals with ASD in distinguishing sounds they generate themselves from external sounds. This may help explain some of the sensory processing issues experienced by ASD patients.

MMN

Mismatch negativity (MMN) is a component of the brain's response that usually happens 100–250 ms after a different sound is heard in a listening test called an auditory oddball paradigm [15, 16]. MMN is derived as a difference wave by subtracting the neural response to a standard (frequent) sound from the response to a deviant (infrequent) sound [15]. This difference wave represents the brain's automatic detection of changes in auditory stimuli, which is important for processing and distinguishing sounds without conscious effort. When examining findings across studies, we see varied patterns of auditory processing in autism. For example, Kujala et al. (2005) found reduced MMN amplitude and prolonged latency, suggesting impairment in the neural basis for speech-prosody processing [25]. In contrast, other studies reported different patterns. Matsuba et al. (2024) found earlier MMN latency indicating enhanced early perceptual neural responses [26], while Ferri et al. (2003) observed larger MMN amplitude in autism [27]. Lepistö et al. (2006) and Vlaskamp et al. (2017) found that MMN responses varied depending on the type of auditory deviant, suggesting differential processing of various sound features [3, 28]. These diverse findings on MMN suggest that individuals with autism may process auditory information in distinct ways, which could help explain the sensory and communication differences commonly observed.

N2

The N2 component is an important part of early auditory processing. It occurs around 150–250 ms after the stimulus and is a negative deflection [17, 29, 30]. The N2 component reflects both automatic and controlled aspects of stimulus detection and discrimination (see Fig. 1). Donkers and his colleagues conducted two studies to explore this component in children with ASD. Their findings shed light on the possible neural mechanisms that contribute to variations in sensory processing in individuals with neurodevelopmental disorders [25, 26]. In their study conducted in 2015, researchers discovered that children with ASD exhibited slightly lower N2 amplitudes in response to standard tones when compared to typically developing children. In their 2020 study, the researchers discovered that children with ASD and developmental delay had significantly reduced N2 responses compared to typically developing controls. This builds upon their previous findings. Interestingly, the N2 latency remained unchanged in all groups, while a decrease in N2 amplitude, particularly when combined with a decrease in the P1 response, was linked to more noticeable sensory-seeking behaviors in children with ASD. Based on these findings, it seems that N2 attenuation could indicate the presence of sensory processing disorders in people with developmental disorders. This could explain the unusual sensory behaviors that are often observed. However, it seems that the N2 attenuation is not specific to autism, which suggests that it may be indicative of more general differences in neurodevelopment rather than processes that are specific to autism. This study highlights the significance of studying early sensory components to better understand how sensory processing works in developmental disorders. It also points out that ERP can be a useful and unbiased way to measure sensory function in these populations.

P3a

The P3a is a waveform that tends to go in a positive direction and is usually seen about 200–300 ms after a new or different sound is heard [17, 31, 32]. P3a is a process that happens automatically when our attention is drawn to unexpected or potentially important sounds [32]. It plays a crucial role in detecting and responding to changes in the sounds around us. The main generator of P3a involves the prefrontal network, which includes the prefrontal cortex, anterior cingulate gyrus, and parietal regions (see Fig. 1).

In a study conducted by Donkers et al. (2015), it was discovered that children with ASD showed a significant decrease in their P3a response, indicating a diminished capacity to respond to new and unfamiliar stimuli [25]. On the other hand, Ferri and colleagues (2003) found that patients with low-functioning ASD had a stronger P3a response, indicating that they might have a tendency to react strongly to auditory changes [27]. In a study conducted by Vlaskamp et al. in 2017, they found that children with ASD showed a higher level of specificity in their response to duration bias, specifically in the P3a component. This indicates that there may be a selective hyperreactivity present in these children [24]. In a study conducted by Vlaskamp et al. in2017, it was discovered that patients with ASD and clinically high-risk psychosis who experienced psychotic transitions had an increase in P3a amplitude [28]. In a study conducted by Lepistö et al. (2006), it was found that children with Asperger's syndrome show a reduced response in the brain's P3a component when it comes to changes in speech pitch and phonemes. However,

this reduced response was not observed in relation to non-speech sounds [3]. These different findings indicate that abnormalities in P3a in individuals with ASD may be influenced by environmental factors and can vary depending on factors such as their level of functioning, the type of stimulus, and any other conditions they may have. It is important to conduct more research to better understand how involuntary attention works in individuals with ASD and how it affects their ability to process auditory information and overall cognitive functioning.

P3b

The P3b is a positive ERP component typically peaking around 300–600 ms after attended target stimuli, with neural generators localized to temporal-parietal areas, hippocampus, and other regions involved in attention and memory updating [17, 33, 34]. It is considered a neural index of attentional resource allocation and context updating (see Fig. 1). Based on the analysis of studies focusing on P3b in individuals with ASD, the findings present a complex and somewhat inconsistent picture. Courchesne et al. (1985) reported reduced P3b amplitude in autism, suggesting impaired cognitive processing of novel stimuli [35]. This finding is partially supported by Sokhadze et al. (2009), who observed prolonged P3b latency to novel stimuli in ASD, indicating delayed sustained attention and context updating [36]. However, Sokhadze et al. (2017) found enhanced P3b amplitude to novel stimuli in ASD, suggesting low selectivity in processing these stimuli [37]. In contrast, Hudac et al. (2018) reported no significant group differences in P3b, implying intact sustained attention to targets in ASD [38]. These mixed results highlight the heterogeneity in P3b responses among individuals with ASD. The variability could be attributed to differences in experimental paradigms, age ranges of participants, and the specific characteristics of the ASD groups studied. Overall, while there is evidence for atypical P3b responses in ASD, the nature of these differences (reduced amplitude, prolonged latency, or enhanced amplitude) appears to vary across studies, suggesting a need for further research to clarify the specific conditions under which P3b abnormalities manifest in ASD and their clinical implications.

Discussion

The findings of this evaluation of ERP research expose a complicated pattern of variations in auditory processing ability in persons with ASD [2, 4], including evidence of both improved and reduced auditory processing ability across ERP components [3, 28]. These variations might help explain sensory sensitivities, poor communication skills, and coexisting issues among those with ASD [39].

Atypicality of early sensory components (e.g., P1 and N1) indicates problems in recognizing auditory changes and novelty as well as in the first registration and storing of auditory inputs [20, 40]. Reduced amplitude and delayed latency of these components in people with ASD may represent changes in the fundamental physiological mechanisms of auditory perception [41] and may cause either auditory hypersensitivity or hyposensitivity [27].

Before attention is directed, mismatch negativity (MMN) is a sign of auditory discrimination; results on the component indicate both improved and reduced auditory processing in persons with ASD [25, 26]. While some studies have observed heightened MMN responses to pitch alterations, suggesting higher cortical sensitivity to auditory stimuli, others have recorded decreased MMN responses to pitch and vowel deviations [3, 28].

Furthermore, showing atypicality in ASD patients were posterior ERP components linked to auditory attention, categorization, and resource allocation including N2, P3a, and P3b [39, 42]. Reduced amplitudes of these components point to problems with contextual information updating, discerning and classifying sounds, and focusing on auditory inputs [36, 37]. Fascinatingly, several investigations have found increased P3a responses to novel stimuli [28], implying maybe hyper responsibility at the attentional level. These results fit the complicated interaction seen in ASD between sensory processing and attentional systems.

The heterogeneity in ERP findings may reflect not only the diversity within ASD but also the influence of co-existing conditions. While this review focuses primarily on characterizing ERP patterns in ASD, it is important to note that conditions such as ADHD, anxiety, depression, and OCD frequently co-occur with ASD [2, 4] and may influence sensory processing patterns. Some studies have suggested associations between altered sensory processing and behavioral challenges in ASD [3], highlighting the potential value of ERP markers in understanding the broader clinical presentation. Future research examining how ERP patterns relate to various co-existing conditions could provide valuable insights for both assessment and intervention approaches.

The results of this review highlight generally the necessity of more study to clarify the brain processes behind variations in auditory processing in ASD. The complicated interaction among sensory processing, attention, and cognitive ability [2, 4] as well as the variety of people with ASD offers chances and difficulties for creating focused treatments and support plans.

Conclusion

This narrative review synthesizes the current research on ERP responses to auditory stimulation in autism, highlighting key findings across various components and stages of processing [2, 4]. The findings reveal a complex pattern of auditory processing differences, with evidence of both enhanced and diminished capabilities across different ERP components.

We have observed atypicality in early sensory components (P1 and N1), suggesting differences in initial auditory registration and change detection [20, 40]. The mismatch negativity (MMN) findings demonstrate variable pre-attentive auditory discrimination abilities, with some individuals showing enhanced responses while others show reduced responses [3, 28].

Later components associated with auditory attention, categorization, and resource allocation (N2, P3a, and P3b) also show atypical patterns [39, 42], suggesting differences in attention to sounds, sound classification, and contextual updating.

This review emphasizes the need for further research to better understand neural mechanisms underlying auditory processing differences in autism. The complex interplay between sensory processing, attention, and cognitive functions, along with individual variability, presents both challenges and opportunities for advancing our understanding and improving support strategies.

Limitations

Although this review offers a thorough summary of the existing research on ERP responses in autism, it is important to recognize certain limitations. The studies included had different experimental designs, stimulus types, and participant characteristics [3, 28]. Rather than viewing these variations as a barrier to understanding, we suggest they reflect the complexity of both autism and auditory processing. These methodological differences have helped reveal the diverse ways that auditory processing may differ in autism.

Furthermore, many studies focused on group-level comparisons between individuals with autism and typically developing controls, potentially overlooking individual variations within the autism population [26, 42]. This emphasizes the importance of considering both group-level patterns and individual differences in future research.

Another limitation is that this study only focused on specific ERP components, which may not fully reflect the complexity of auditory processing in autism. In the future, researchers may explore other electrophysiological measures such as oscillatory activity and functional connectivity analysis. This will help them gain a deeper understanding of the neural mechanisms involved.

In conclusion, this review highlights the importance of considering indicators of auditory processing in the study and management of other conditions that often co-occur with autism. However, it is worth noting that we still do not fully understand the exact causal relationship between these factors. Conducting longitudinal studies would help to better understand how these associations develop over time.

Directions for Future Research

After considering the findings and limitations discussed in this review, we can suggest several areas for future research:

Thank you for your valuable suggestions to strengthen the future research recommendations section. We have reorganized and enhanced this section to provide more specific details and clearer conceptual grouping. The revised section now includes:

1. Understanding ASD origins and population diversity
    - Conduct large-scale, multi-center studies with diverse ASD populations, explicitly including racially diverse individuals, those with profound autism, and individuals with co-existing intellectual disabilities
    - Use ERP measures (P1, N1, MMN) to investigate neural mechanisms underlying ASD development and potential early biomarkers
    - Examine how ERP profiles reflect genetic and environmental influences on auditory processing in ASD
2. Advanced EEG analysis approaches
    - Apply advanced time-frequency analysis and machine learning algorithms to ERP data
    - Implement advanced statistical approaches to capture individual differences
    - Integrate resting-state EEG with ERP measures for comprehensive assessment
3. Clinical assessment and development
    - Conduct longitudinal studies examining ERP component changes from childhood through adulthood
    - Study ERP patterns' relationship with behavioral outcomes and core ASD symptoms
    - Examine how factors like age, cognitive ability, and language skills influence ERP patterns
4. ERP-informed intervention applications

- Educational Settings: Guide classroom modifications and learning strategies based on individual ERP profiles
- Clinical Applications: Develop targeted interventions and monitor effectiveness using ERP measures
- Daily life applications: Inform workplace modifications and sensory-friendly environment design
- Use ERP components as objective markers for treatment response and intervention planning

Key References

- Chen Y, Tang E, Ding H, Zhang Y: Auditory Pitch Perception in Autism Spectrum Disorder: A Systematic Review and Meta-Analysis. Preprints 2022, 202206.0212.v1.

  ○ This systematic review and meta-analysis provides a comprehensive overview of auditory pitch perception in autism spectrum disorder, synthesizing findings from multiple studies to offer insights into this sensory processing aspect of ASD.

- Matsuba ESM, Prieve BA, Cary E, Pacheco D, Madrid A, McKernan E, Kaplan-Kahn E, Russo N: A Preliminary Study Characterizing Subcortical and Cortical Auditory Processing and Their Relation to Autistic Traits and Sensory Features. Journal of Autism and Developmental Disorders 2024, 54:75–92.

  ○ This study examines both subcortical and cortical auditory processing in autistic individuals, providing insights into the relationship between auditory processing, autistic traits, and sensory features.

- Parkinson S, Schumann S, Taylor A, Fenton C, Kearney G, Garside M, Johnston D: SoundFields: A Virtual Reality Home-Based Intervention for Auditory Hypersensitivity Experienced by Autistic Children. Applied Sciences 2023, 13:6783.

  ○ This study evaluates a novel virtual reality intervention for auditory hypersensitivity in autistic children, demonstrating the potential of home-based digital interventions for addressing sensory challenges in autism.

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Data Availability No datasets were generated or analysed during the current study.

Declarations

Competing Interests The authors declare no competing interests.

Human and Animal Rights and Informed Consent This article contains no human or animal subjects' studies conducted by any of the authors.

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